Movers & Shakers in the U.S. Power System – Distributed Resources

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Distributed Resources are Transforming the U.S. Power System

- >14 million electric customers are supplying power back into the grid.
- Distributed solar capacity nearly doubled in the past 2 years to (to ~14 GW today, ~1% of total U.S. generating capacity).
- >80 GW of combined heat and power now accounts for ~8% of total U.S. generating capacity.
- >16 million customers participate in wholesale or utility demand response or time-varying rate programs.
- Millions of consumers maintain back-up generators or energy storage systems.
- The charging cycles of 535,000 EVs are now being managed.

Source: DOE Electricity Advisory Committee, Smart Grid Subcommittee

The Power of Consumer Action

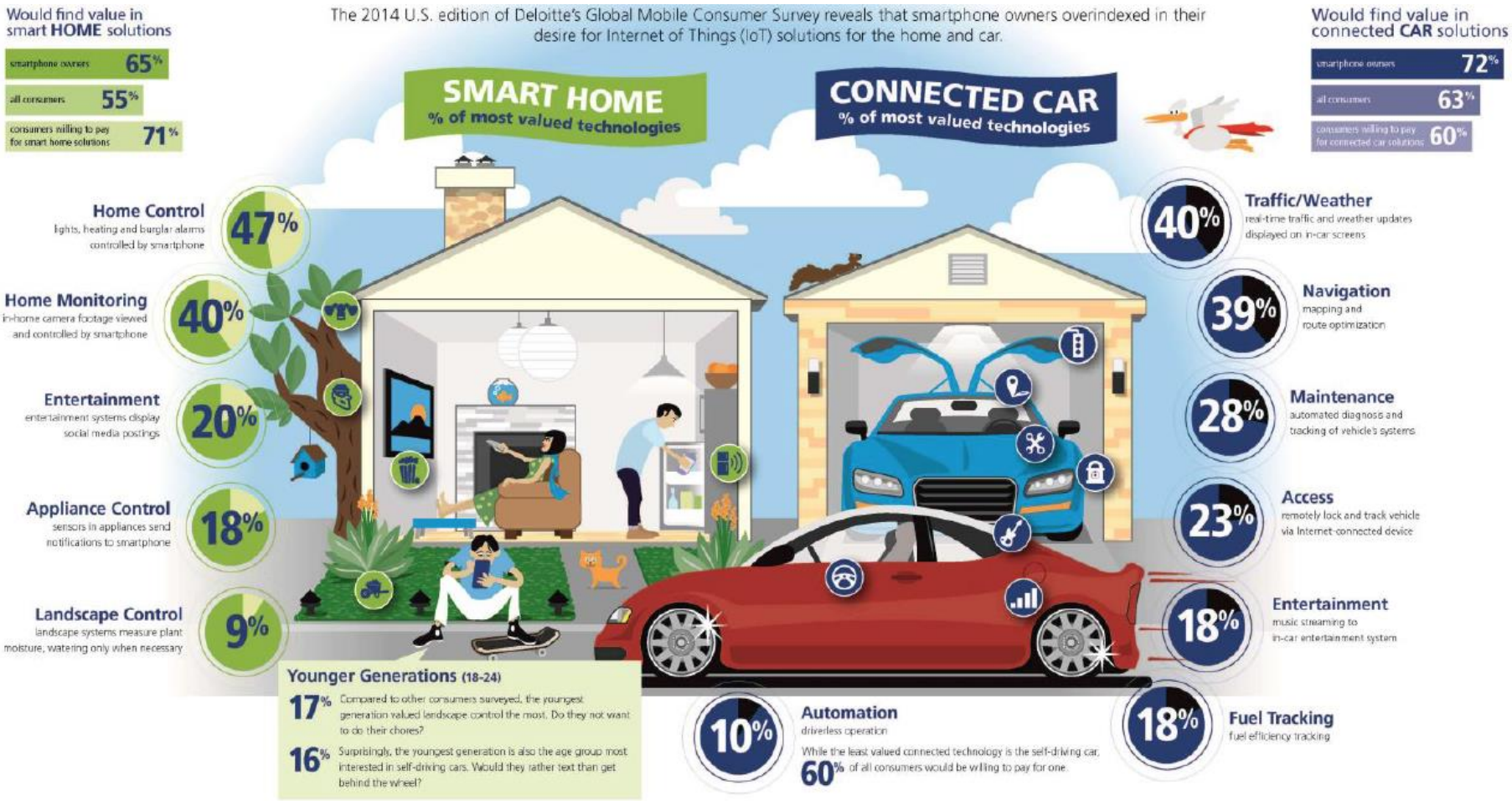
Smart meters provide frequent data collection and two-way communication:

- ✓ Powerful when combined with real-time electricity pricing
- ✓ WiFi enabled; control from computers & cell phones
- ✓ Can interface with in-home, in-office, and smart phone displays of online consumption data
- ✓ Detailed usage summaries available on line

Sensors for temperature, humidity, motion, and light eliminate wasted energy (and improve comfort).

Google/Nest Learning Thermostat

Implications of Digital Control and Distributed Energy



Deloitte's Vision: The Internet of Things Moves In

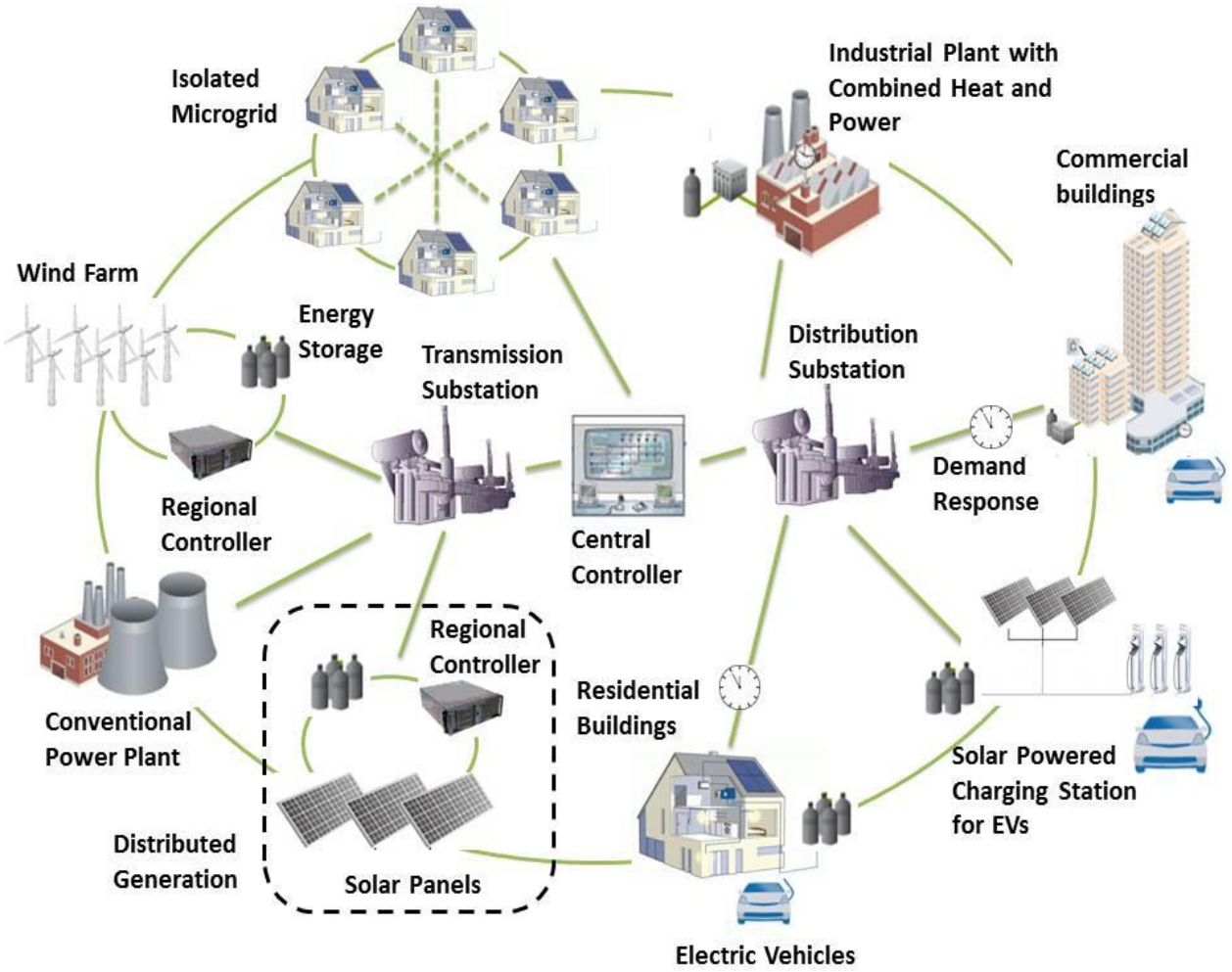
Tesla's Sustainable Future

Distributed, connected vehicles

1,000,000 EVs x 10kW On-Board Charger
= 10 GW Controllable Load

Source: Mateo Jaramillo, Tesla, June 19, 2017

The Challenge: Integrating Distributed Energy Resources Into the Grid



Source: Brown, Marilyn A. 2014. "Enhancing Efficiency and Renewables With Smart Grid Technologies and Policies," *Futures: The Journal of Policy, Planning and Futures Studies*, 58: 21-33.

Distributed Resources Require a Smart Grid and Smart Policies

Digital communications, information systems, and automation detect and react to grid conditions
— not just hearing but also speaking.

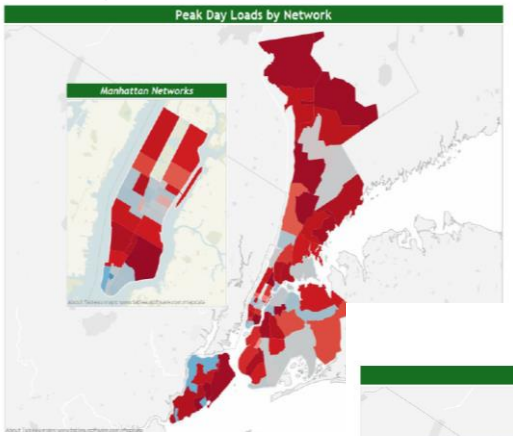
Smart grids:

- Facilitate the integration of diverse supply-side resources
- Support the integration of distributed generation on the customer side
- Promote more active engagement of demand-side resources
- Allow dynamic pricing

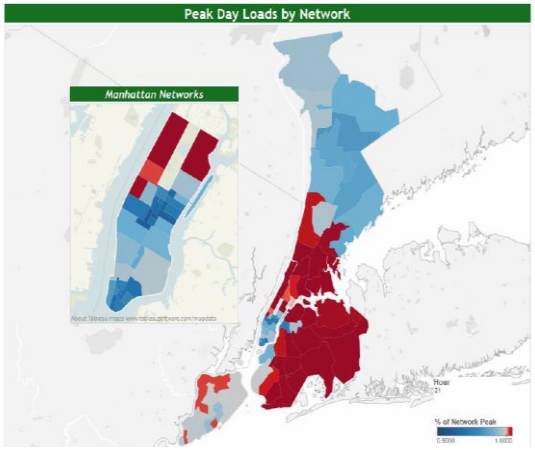
Geospatially Managed Demand

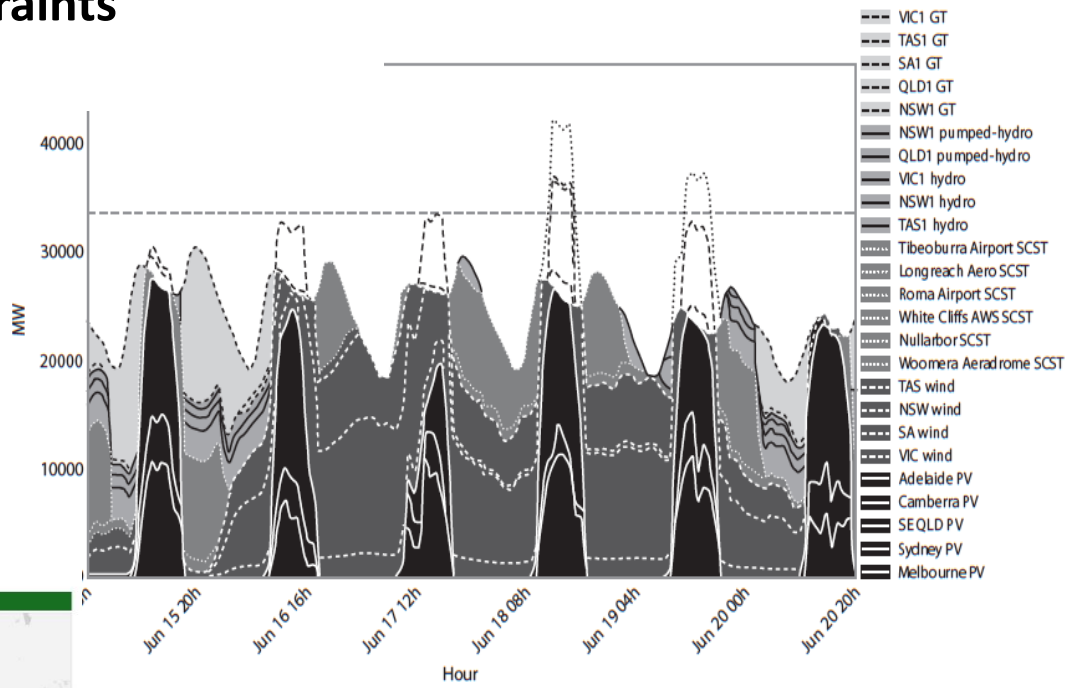
- Peak day loads by network are shifting
- Resources need to be deployed into specific zones
- Dispatched to address local constraints
- Managed in real time

2 pm



9 pm

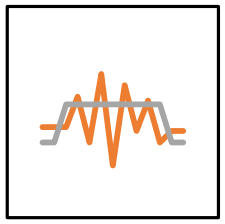




Variations in Renewable Electricity Supply and Demand for Australia

Sovacool, Brown, and Valentine. 2016.
Fact and Fiction in Global Energy Policy

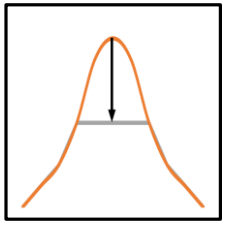
Distributed Resources can also Support a Smart Grid



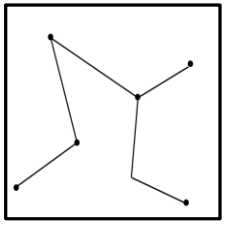
Capacity Firming

T&D Support

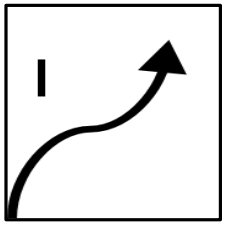
Emergency Backup



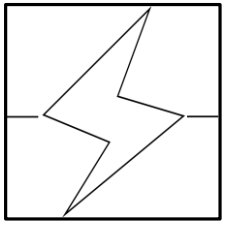
Peak Shaving



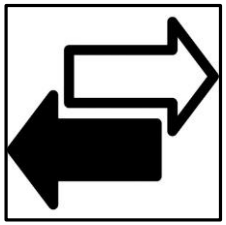
Microgrid



Load Shifting



Ancillary Services

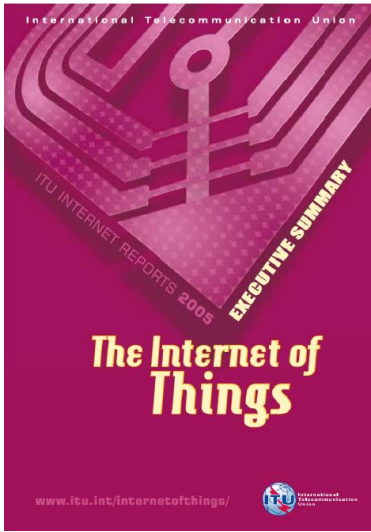


Demand Response

We need to put our grid on steroids

Will distributed resources improve or challenge power system reliability, affordability, and sustainability?

- Ensuring the cyber security of the grid has grown more complex given the development of the “Internet of Things” and increasingly global supply chains.
- The notion of reliable service has expanded to include the importance of a resilient grid, particularly in response to extreme weather conditions and widespread and sustained outages.
- IoT developers envisage a world where billions of devices oversee the entire energy network: smart lights, smart meters, and other devices, all working in concert to balance production and demand.



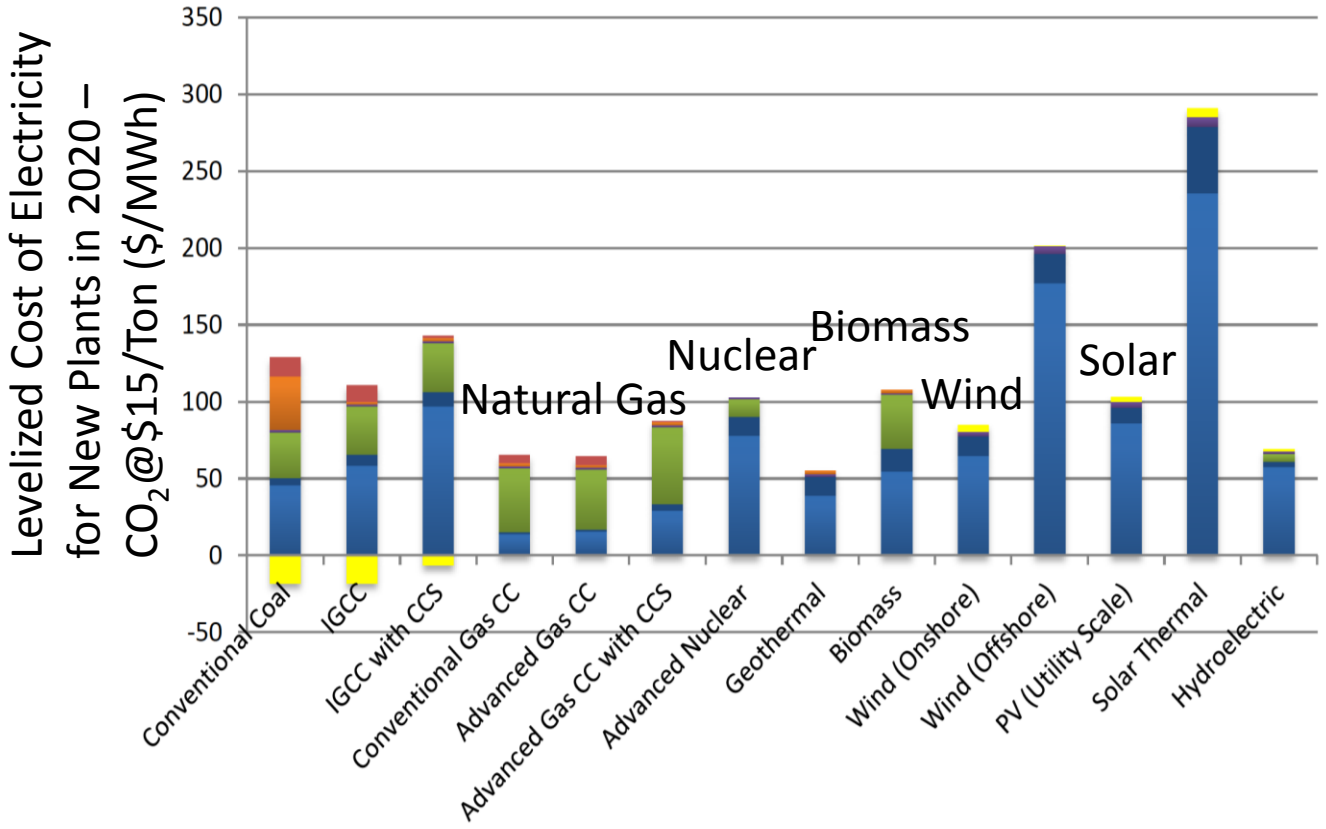
Investment Cost and Affordability: Constant Concerns

Two competing cost pressures:

- repairing and replacing aging energy infrastructure
- incorporating “smart” technologies and distributed energy assets

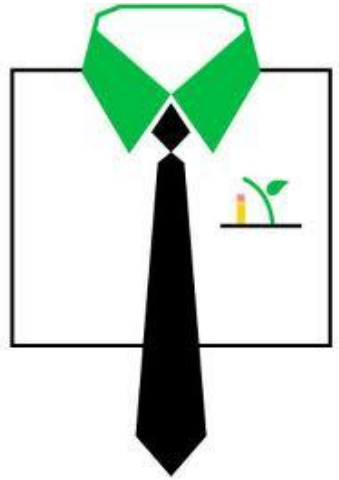
It's Hard to Compete with Natural Gas

Wind and utility-scale solar are now cheaper than nuclear & coal. But what about the demand side of the meter?



Source: National Academies. 2016. The Power of Change: Innovation for Development and Deployment of Increasingly Clean Electric Power Technologies

Changing the Jobs Narrative



The U.S. has about 75,000 jobs in coal mining. Automation has had a major impact on this workforce: autonomous trucks work the Powder River Basin….

See: 30-minute CNN discussion: 175,000 live “hits”

https://www.facebook.com/cnn/videos/10156318782866509/?hc_ref=NEWSFEED

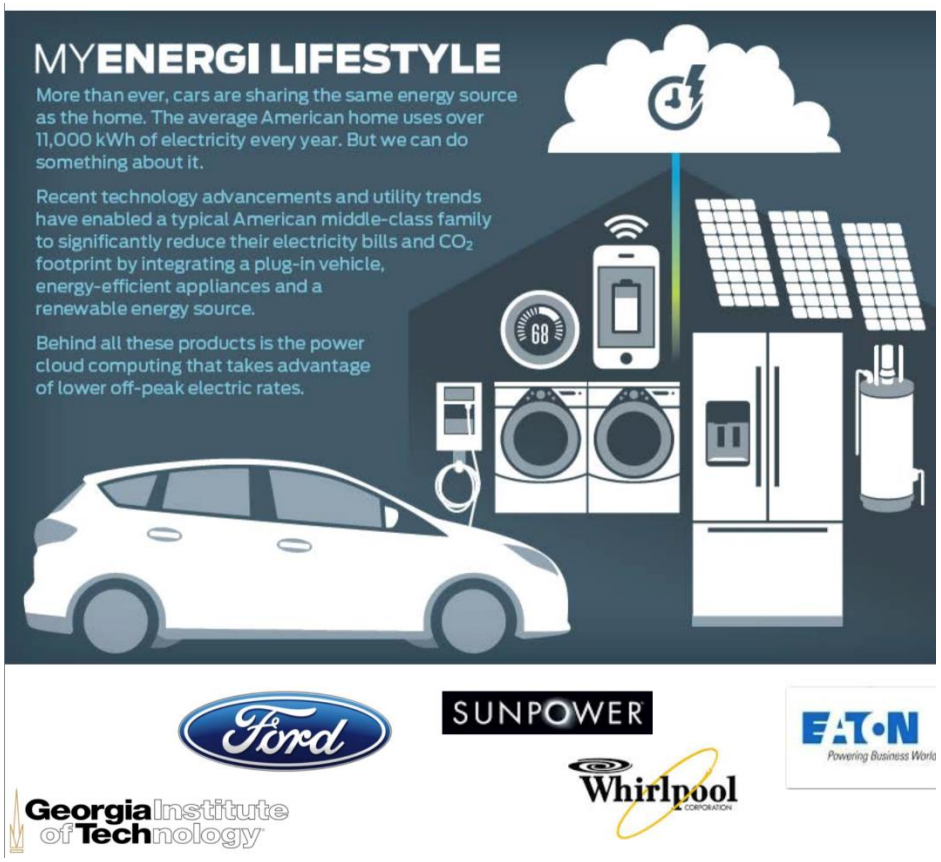
Energy Efficiency Jobs

Nearly 1 million U.S. workers spend a majority of their time installing energy-efficient equipment and services.

~66,200 Georgians work in energy efficiency related businesses.

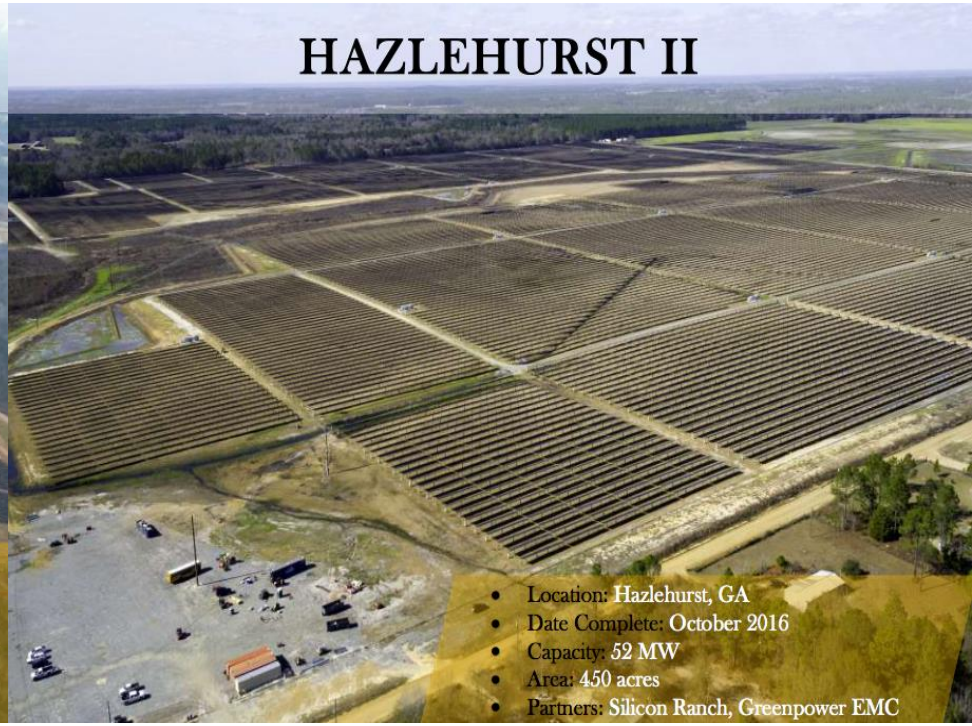
Technologies include:

- Advanced windows & insulation
- High efficiency HVAC
- Smart thermostats
- Efficient lighting and controls
- Energy Star appliances, etc.



Source: Environmental Entrepreneurs (E2) and E4 The Future. 2016. *Energy Efficiency Jobs in America*.

Solar Jobs



- The U.S. has about 260,000 workers in the solar industry
- (3,900 in Georgia in 2016).
- One out of every 50 new jobs added in the U.S. in 2016 was created by the solar industry.

Source: The Solar Foundation. 2017. *National Solar Jobs Census 2016*, available at: SolarJobsCensus.org.

How to Drive Change: The "Carbon Dividends Plan?"

A Carbon Tax with Revenues Recycled to Households

THE WALL STREET JOURNAL.

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A Conservative Answer to Climate Change

Enacting a carbon tax would free up private firms to find the most efficient ways to cut emissions.

By George P. Shultz and James A. Baker III

Updated Feb. 7, 2017 7:07 p.m. ET

"I really don't know the extent to which it is man-made, and I don't think anybody can tell you with certainty that it's all man-made, … the **risk** is sufficiently strong that **we need an insurance policy** and this is a damn good insurance policy."

James Baker, February, 2017

With Energy Efficiency, CO_2 & Energy Costs Can be Cut

Types of policies studied:

- Carbon caps: "Clean Power Plan"
- Carbon taxes: "Carbon Dividends Plan"
  - redistribute taxes on a per capita basis vs
  - redistribute per source of CO_2.

Supply + demand policies:

Climate Policy:	Cost per ton of CO_2 Reduction
Carbon Cap	$39.13
Carbon Cap + EE	-$26.30
$10 Carbon Tax	$8.11
$10 Carbon Tax + EE	-$28.63

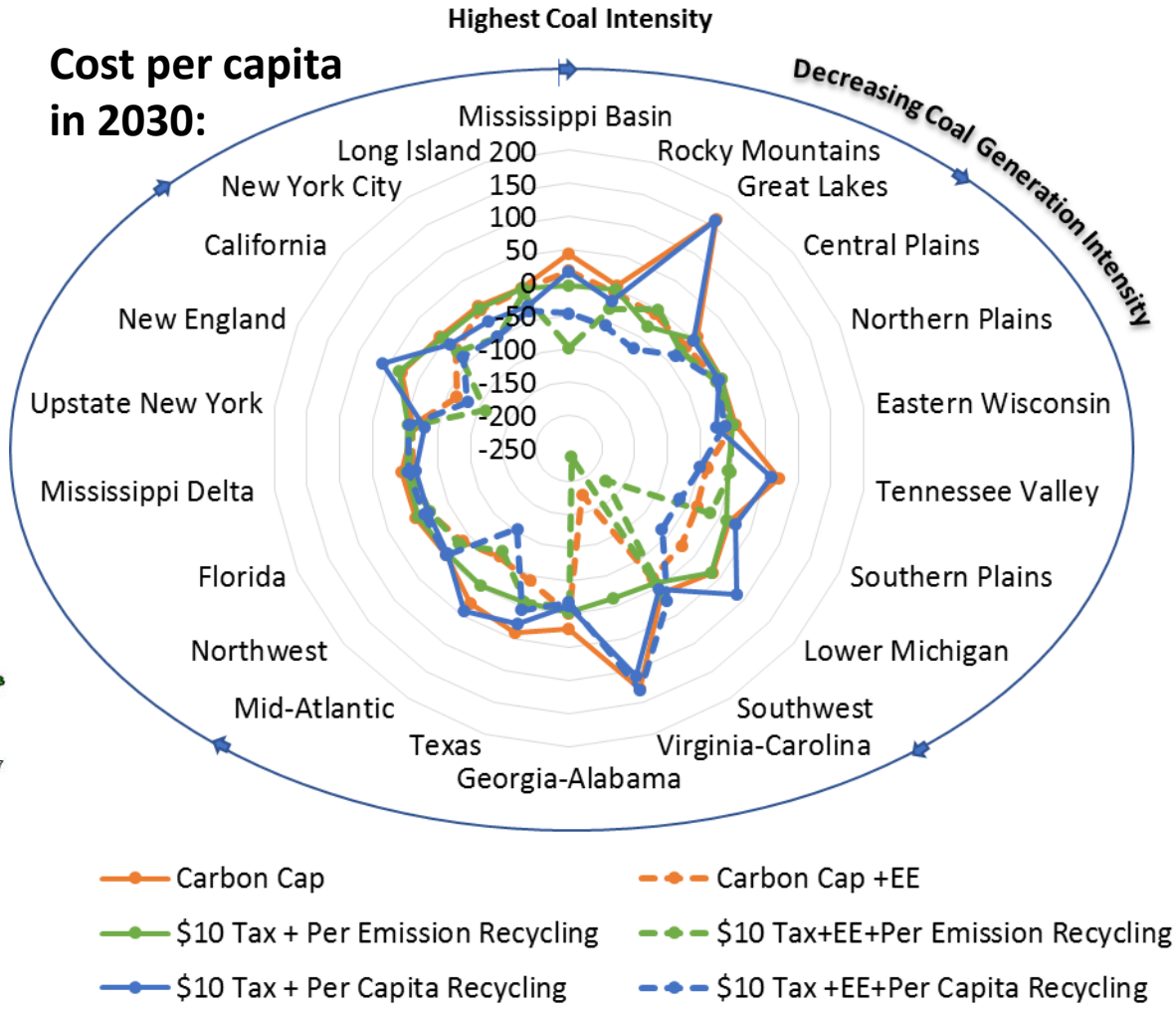
Cost of climate policy = utility resource costs + EE costs + administrative costs – carbon tax recycling (in $2013)

Source: Brown, M. A., Kim, G., Smith, A. M., & Southworth, K. (2017). Exploring the impact of energy efficiency as a carbon mitigation strategy in the US. Energy Policy, 109, 249-259.

Regional Winners and Losers: Policy Design Matters

The Carbon Dividends Plan would transfer wealth from regions with coal plants.

Cost per capita in 2030:



Electricity Market Module Regions

Estimated impacts range from a cost of ~$150 per capita to a benefit of ~$250 per capita.

Conclusions

Movers and shakers are causing a paradigm shift.

We can grow the economy, create jobs, improve human health, and reduce CO_2.

But can we protect the grid and stabilize the climate?

A great deal is at stake, and policy design matters.

For More Information—and some late night reading??

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